Illinois Department of Transportation
2300 South Dirksen Parkway / Springfield, Illinois / 62764

BDE PROCEDURE MEMORANDUM

NUMBER: 24-01

SUBJECT: Earthwork Quantities

DATE: August 6, 2001

This memorandum supercedes part of the information found in Section 64-2.04(a) of the BDE Manual and provides new and additional guidance on the use of Earthwork Pay Items.

Background

The issuance of the July 1, 1994 edition of the Standard Specifications for Road and Bridge Construction changed the method the Department utilized for paying for some Earthwork quantities. Under these specification the Earth and Rock Excavation pay items were used for excavation and transportation of suitable excavated material to embankment locations or the excavation, transportation, and disposal of excavated material. Embankment consisted of the construction of embankments by depositing, placing, and compacting materials of acceptable quality. Since the inception of the revised specifications several problems have arisen. These include lack of required information in contract documents and no equitable method for price adjustments in the Embankment pay item when plan quantities vary due to the use of the combination of on-site and off-site material. Problems have also developed with Topsoil pay items and the confusion and difficulty in utilizing on-site and off-site material.

With the issuance of a new Standard Specifications for Road and Bridge Construction effective January 1, 2002 several items relating to Earthwork have been revised. This Procedure Memorandum is intended to provide guidance on the usage of the new or revised specifications and pay items.

Applicability

The following procedures are applicable to all projects let after January 1, 2002 that involve Earth and Rock Excavation, Borrow and Furnished Excavation, Embankment, and Topsoil and Compost.

Procedures

The following procedures establish design guidelines for use of the earthwork pay items contained in the Standard Specifications for Road and Bridge Construction, effective January 1, 2002.

- Earth and Rock Excavation. This work shall consist of the excavation and transportation of suitable excavated material to embankment locations throughout the limits of the contract or the excavation, transportation, and disposal of excavated material. This work does not include excavation for structures or channel excavation.

  Quantities should be calculated in the normal manner according to the applicable portions of Section 64-2 of the BDE Manual.

  If the Earth or Rock Excavation is to be used on the project in an embankment the suitability and/or stability of the excavated material must be examined. The amount of suitable excavated material to be used in embankments shall be shown in the Earthwork Schedule and paid for as Earth Excavation or Rock Excavation. If a portion or all of the excavated material is determined to be unsuitable or unstable, that quantity shall be calculated and paid for as Removal and Disposal of Unsuitable Material.

  When possible, a shrinkage factor should be determined for the suitable excavation to be used as embankment. The shrinkage factor will determine the final volume of the excavated material once it is compacted within the embankment. This quantity shall then be used to determine the amount of material either to be wasted or to be hauled in from off-site. The District Materials Engineer should be contacted concerning the determination of a shrinkage factor. When a shrinkage factor is determined it shall be shown on the plans. If no shrinkage factor is determined, a shrinkage factor of 25% shall be assumed.

  If topsoil is to be excavated and used on the project this quantity shall be paid for as Topsoil Excavation and Placement and not included in the Earth Excavation quantity. Cross sections should show the different cut quantities.

- Borrow and Furnished Excavation. Borrow and Furnished Excavation shall consist of excavating suitable materials obtained from borrow locations furnished by the Contractor and transporting the materials to various locations throughout the limits of the contract.

  The only difference between Borrow Excavation and Furnished Excavation is the Method of Measurement.

  - ♦ Borrow Excavation will be measured in its original position by taking cross sections of the borrow site before the work is started and again after it has been completed. The volume in cubic yard (cubic meters)

of material moved will be computed by the method of average end areas. When possible, the shrinkage factor of the Borrow Excavation shall be determined. The shrinkage factor will determine the plan quantity of material to be excavated from the borrow site, which is the pay quantity, that will provide the required volume once it is compacted in the embankment. The District Materials Engineer should be contacted regarding the determination of a shrinkage factor. When a shrinkage factor is determined it should be shown on the plans. If no shrinkage factor is determined, a shrinkage factor of 25% shall be assumed.

- Furnished Excavation will be determined either by an agreement to plan quantity or by measurement in its final place. For measurement in place, compute the volume of the compacted material in cubic yards (cubic meters) using the average end areas method and then subtract the final pay quantity of Earth and Rock Excavation, adjusted by a shrinkage factor of 25% or as shown on the plans, as discussed above. Excavation quantities included in the cost of other items shall also be deducted.

The use of Borrow Excavation or Furnished Excavation will be at the designer's discretion, however the designer should consult with the District Materials Engineer and District Construction Engineer. In determining which pay item to use, the following should be considered:

- Do not use Borrow Excavation and Furnished Excavation on the same project; use one or the other.

- Furnished Excavation, should be used:
  - on projects where a small amount of borrow material is required, [< 50,000 cubic yards (40,000 m^3)];
  - on bridge projects, or minor realignments, and 3R type improvements;
  - on projects in urbanized areas where borrow may come from many sources;
  - where no suitable borrow locations are apparent; or
  - where use of commercial borrow sites or multiple borrow sites are anticipated.

- Borrow Excavation should be used:
  - on projects where a significant amount of borrow material is required, [> 50,000 cubic yards (40,000 m^3)]; or
  - where a borrow site may be readily available.

- Embankment. This work shall consist of the construction of embankments by depositing, placing, and compacting earth, stone, gravel, or other materials of acceptable quality above the natural ground or other surface. The materials incorporated are from Earth Excavation, Rock Excavation, Borrow Excavation, Furnished Excavation, or other sources as mentioned in the contract documents.

  Embankment will not be paid for directly but shall be considered as included in the various items of excavation, and their construction included in the unit prices of these items.

- Topsoil and Compost. This work shall consist of furnishing, excavating, and placing topsoil, special types of topsoil or compost/topsoil blend.

  The use of topsoil on projects will be paid for either as Topsoil Excavation and Placement or as Topsoil Furnish and Place. The designer will decide which pay item(s) to use and should consult the District Landscape Architect, District Materials Engineer, and District Construction Engineer for assistance. Topsoil Excavation and Placement involves the use of topsoil obtained from within the project limits. Topsoil Furnish and Place requires the Contract to obtain topsoil from an off-site location. The use of topsoil within the project limits is encouraged and recommended. In determining contract quantities on-site material should be utilized first and if additional quantities are required off-site material should be calculated. Therefore, on some projects both pay items may be used.

  The quantity of Topsoil Excavation and Placement is not included in the Earth Excavation quantity.

- Earthwork Schedule. Earthwork schedules shall be shown on all plans involving earthwork pay items. The schedule should show:
  - Cuts and Fills;
  - Earth and Rock Excavation quantities;
  - Removal and Disposal of Unsuitable Material quantity;
  - Borrow or Furnished Excavation quantity. (Note that Borrow Excavation is calculated in the uncompacted state so a shrinkage factor must be assumed to arrive at this quantity from the known fill required. Furnished Excavation is calculated in its final place [compacted state]);
  - Shrinkage factors for Earth Excavation and Borrow Excavation; and
  - Topsoil Excavation and Placement, Topsoil Furnish and Place, and/or Compost Furnish and Place Quantities.

- Equations
  (Note: all equations assume a shrinkage factor of 25%.)

  - Earth Excavation used as Embankment = Earth Excavation X .75

If the quantity of Earth Excavation used as Embankment is less than the Embankment quantity required then one of the following equations shall be used.

- Furnished Excavation = Embankment – (Earth Excavation X .75)

- Borrow Excavation = [Embankment – (Earth Excavation X .75)] X 1.25

- Examples

  - Example 1

Earthwork Schedule

1 Location	2 Earth Excavation	3 Earth Excavation Adjusted for Shrinkage	4 Embankment	5 Earthwork Balance Waste (+) or Shortage (-)
	Cubic Yard	Cubic Yard	Cubic Yard	Cubic Yard
Sta. 100+00 to 105+00	500	375	100	+275
Sta. 105+00 to 110+00	400	300	100	+200
Sta. 110+00 to 115+00	500	375	200	+175
Side Road A	200	150	300	-150
Total	1600	1200	700	+500

Column 1,2 & 4 – Location and Quantities from Cross Sections,
Cut = Earth Excavation Fill = Embankment

Column 3 – Quantity of Earth Excavation (Cut) Adjusted for a shrinkage factor of 25%

Column 5 – Earthwork required. (-) = Quantity of Fill or Embankment needed (Furnished or Borrow Excavation), (+) = Quantity to be wasted

Since the Earth Excavation Quantity is greater than Embankment needed only pay item is for Earth Excavation, no pay item for borrow or furnished Excavation is needed.

Pay Item

EARTH EXCAVATION 1600 Cubic Yards

- Example 2

Earthwork Schedule

1 Location	2 Earth Excavation	3 Earth Excavation Adjusted for Shrinkage	4 Embankment	5 Earthwork Balance Waste (+) or Shortage (-)
	Cubic Yard	Cubic Yard	Cubic Yard	Cubic Yard
Sta. 320+00 to 325+00	100	75	275	-200
Sta. 325+00 to 330+00	200	150	125	+25
Sta. 330+00 to 335+00	150	112.5	300	-187.5
Side Road X	50	37.5	250	-212.5
Total	500	375	950	-575

Column 1,2 & 4 – Locations and Quantities from cross sections,
Cut = Earth Excavation Embankment = Fill

Column 3 – Quantity of Earth Excavation (Cut) Adjusted for a shrinkage factor of 25%

Column 5 – Earthwork required. (-) = Quantity of Fill or Embankment Needed (Furnished or Borrow Excavation), (+) = Quantity to be wasted

The Earth Excavation quantity is not great enough to account for all Embankment (Fill) needed. Therefore, additional earth is required from off-site either as borrow or furnished excavation.

Furnished Excavation is measured in its final (compacted) state. Borrow Excavation is measured at the borrow site and therefore the borrow quantity must allow for shrinkage (assume 25%). Borrow = 575 cu. yd. X 1.25 = 718.75.

Pay Items

EARTH EXCAVATION - 500 cubic yards
FURNISHED EXCAVATION - 575 cubic yards

or

EARTH EXCAVATION - 500 cubic yards
BORROW EXCAVATION - 720 cubic yards

- Example 3

Earthwork Schedule

1 Location	2 Earth Excavation	3 Rock Excavation	4 Unsuitable or Unstable Material	5 Excavation to be used in Embankment Adjusted for Shrinkage	6 Embankment	7 Earthwork Balance Waste (+) or Shortage (-)	8 Topsoil Excavation and Placement	9 Topsoil Furnish and Place
	Cubic Yard	Cubic Yard	Cubic Yard	Cubic Yard	Cubic Yard	Cubic Yard	Cubic Yard	Square Yard
Sta. 410+00 to 430+00	3,000		1,000	16,000	10,000	-8,400	600	
Sta. 430+00 to 450+00	2,000	500		2,100	8,000	-5,900	200	300
Sta. 450+00 to 470+00	5,000			4,000	2,000	+2,000	200	400
Frontage Road	1,000			800	5,000	-4,200	300	
Total	11,000	500	1,000	8,500	13,000	-16,500	1,300	700

Shrinkage Factors: Earth Excavation: 20%
Rock Excavation: 0%
Borrow Excavation: 30%

Column 1 – Location from plans.
Column 2 – Cut quantities from cross sections, this does not include topsoil excavation.
Column 3 – Quantities from cross sections.
Column 4 – Cut material that is determined to be either unstable or unsuitable for use in embankment.
Column 5 – Earth and Rock Excavation quantities that are to be used as fill material in embankment. Includes deduction for unsuitable material.
Earth Excavation shrinkage factor was determined to be 20%.
Rock Excavation shrinkage factor was determined to be 0%.
Column 6 - Quantities from cross sections.
Column 7 - Off-site material needed or material to waste.
Column 8 - Quantities from cross sections, these quantities are not included in earth excavation or embankment.
Column 9 - Quantities required from off-site to complete project, quantities are not included in borrow or furnished excavation.

On projects in which cut material is paid for with multiple pay items (example: Earth Excavation and Rock Excavation) the total quantity of cut material shall be calculated to determine the quantity of off-site material required for embankment. Each item may have a different shrinkage factor.

On projects in which topsoil is to be paid for the topsoil quantities are not included in any other pay items (earth excavation, furnished excavation, etc.) The total quantity of topsoil needed shall be calculated first. Next calculate the amount of topsoil available within the project limits. If not enough topsoil is available on the project then the additional amount shall be obtained from off-site and paid for as Topsoil Furnish and Place. A shrinkage factor may be used for topsoil but is not usually required.

Borrow Excavation quantity is 16,500 X 1.30 = 21,450 cubic yards. If Furnish Excavation were used the quantity would be 16,500 cubic yards.

Pay Items

EARTH EXCAVATION	11,000 cubic yards
ROCK EXCAVATION	500 cubic yards
REMOVAL AND DISPOSAL OF UNSUITABLE MATERIAL	1,000 cubic yards
BORROW EXCAVATION	21,450 cubic yards
TOPSOIL EXCAVATION AND PLACEMENT	1,300 cubic yards
TOPSOIL FURNISH AND PLACE	700 square yards

Engineer of Design and Environment Michael L. Hine